

REMARKS

Claims 1-17 are pending in the Application. Claims 18-20 are added with this Amendment. Support for new claim 18 is found in original claim 6, and in the Specification at: page 4, last 3 lines; page 6, last 2 lines to page 7, line 2; page 7, lines 25-27; and page 8, lines 9-14. Support for newly added claim 19 is found in claim 17. Support for newly added claim 20 is found in original claim 7. No new matter is added with this Amendment.

Applicants' invention is directed, inter alia, to a method of providing a seed layer substantially free of discontinuities by contacting a discontinuous seed layer with an alkaline copper electroplating bath comprising copper pyrophosphate. Sufficient current density is then applied to provide a metal seed layer substantially free of discontinuities. An advantage of the present invention is that the electroplating bath can be used to provide a seed layer substantially free of discontinuities and to fill the apertures with copper.

Claims 1, 2, 4, 6, 7, 9 and 11-13 have been rejected under 35 USC § 103(a) as being unpatentable over Cohen in view of Mahapatra. Applicants respectfully traverse.

The Official Action again states at page 3 that Cohen, referring to Figs. 3 and 4 and related text, "discloses a method of manufacturing an electronic device (inherently an article produced) comprising the step of contacting a metal seed layer having discontinuities 126 disposed on a substrate 112 having one or more apertures having a size of $\leq 1 \mu\text{m}$ with a copper electroplating bath" [Emphasis added.] Applicants respectfully disagree. Cohen is directed to depositing a conformal seed layer over a non-conformal, i.e. PVD, seed layer. Such conformal seed layers are only disclosed to be deposited by CVD or electroless plating. These conformal seed layers are continuous. Nowhere in the Cohen patent is *electroplating* a copper layer on a *discontinuous* seed layer mentioned. Figs. 3 and 4 are described in Cohen starting at col. 6, line 63. The description of the seed layers in Figs. 3 and 4 is found in Cohen at col. 7, lines 52-67. Seed layer 126 is clearly referred to as "non-conformal" (see col. 7, line 52) and is obtained by PVD (col. 7, lines 53-54). Seed layer 128 is clearly referred to as "conformal" (col. 7, line 60) and is deposited by CVD or *electroless* technique (col. 7, lines 61-62). It is clear throughout

Cohen that only CVD and electroless copper plating are disclosed for depositing a continuous seed layer on a discontinuous seed layer. For example, see also column 5, lines 19-21, which states: "Conformal seed layer 20 can be preferably deposited using a CVD technique, but it can also be deposited by using an electroless technique." Further, at col. 2, lines 21-25 and at col. 3, lines 38-39, Cohen only refers to CVD and *electroless* techniques as providing conformal seed layers. The only discussion in Cohen regarding electroplating baths is concerned with the plating bath used to fill the features after the 2 seed layers are deposited. Thus, Cohen does not disclose, suggest or otherwise mention a copper *electroplating* bath for depositing or repairing a *seed layer*.

In addition, Cohen does not repair a discontinuous seed layer. Rather, Cohen deposits a *second* seed layer which is conformal on a first seed layer which is non-conformal. In this regard, the first seed layer is disclosed in Cohen as being deposited by a PVD technique and the second seed layer is disclosed as being deposited as by a non-conformal technique. The only non-conformal techniques disclosed are CVD techniques and *electroless* copper plating. The second non-conformal seed layer of Cohen is continuous. Only after this second seed layer is deposited is the device contacted with a copper *electroplating* bath. Thus, Cohen only discloses or suggests contacting a continuous seed layer with a copper electroplating bath. Not only does Cohen fail to suggest an alkaline copper electroplating bath containing pyrophosphate (as acknowledged by the Official Action at page 4), but Cohen also fails to disclose or suggest contacting a *discontinuous* seed layer with a copper electroplating bath.

Mahapatra is relied upon for the teaching of the components of a copper pyrophosphate bath. See the official Action at page 4. However, this teaching still does not suggest contacting a discontinuous seed layer with a copper electroplating bath. The Mahapatra patent fails to disclose discontinuous seed layers, and, in fact, fails to recognize the problems associated with discontinuous metal seed layers. Such discontinuous metal seed layers are particularly problematic on substrates having one or more $\leq 1 \mu\text{m}$ apertures. This patent neither discloses nor suggests substrates having $\leq 1 \mu\text{m}$ sized apertures. In fact, Mahapatra fails to disclose or suggest substrates having apertures at all. Mahapatra fails to disclose or suggest integrated circuit devices.

There is nothing in Cohen or Mahapatra, either alone or in combination, that would lead one to combine these references. Even if one did combine them, one would at best first deposit a non-conformal PVD seed layer followed by a second seed layer which is conformal and already continuous and only then contacting such second seed layer with the copper electroplating bath of Mahapatra.

There is no motivation in this combination of references to use an alkaline copper electroplating bath to repair a discontinuous seed layer. Further, there is nothing in these references that teaches or suggests using an alkaline copper pyrophosphate electroplating bath to both repair a discontinuous copper seed layer and deposit copper to fill an aperture.

The Official Action lists Brighton, Tuckerman and Uzoh as examples showing that electroless plating and electroplating are interchangeable to form metal *on* a seed layer. However, none of these references recognize that an alkaline copper pyrophosphate electroplating bath can *both* repair a discontinuous seed layer and deposit metal to substantially fill the apertures on a substrate. In this way, a discontinuous seed layer in an aperture is repaired *and* copper metal is deposit in the aperture to substantially fill the aperture in one step. See, for example, Applicants' claims 18-20. Separate steps of depositing second seed layers and separate steps of repairing a seed layer in one copper plating bath and then filling apertures in a second copper plating bath can be avoided by the present invention. Such could not be predicted from a combination of Cohen and Mahapatra. Applicants submit the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Claims 1, 2, 4, 6, 7, 9 and 11-15 have been rejected under 35 USC § 103(a) as being unpatentable over Tsai in view of Mahapatra. Applicants respectfully traverse.

Tsai is directed to a method of preventing copper migration by filling features with a carbon-doped copper deposit. In order to achieve such carbon-doped copper deposit, the copper plating bath must have a certain carbon concentration. Only in this way can the purpose of Tsai, i.e. to prevent copper electromigration, be fulfilled. The only copper electroplating bath described is an acid bath (pH of 0.1 to 4). No other copper electroplating baths are taught or suggested by Tsai. Thus, there is nothing in Tsai that teaches or suggests Applicants' claimed invention.

Mahapatra is discussed above. This patent does not fill the deficiencies of Tsai.

There is no motivation in either of these references to combine them to repair a seed layer and more specifically to repair a discontinuous copper seed layer in an aperture and deposit copper into the aperture to substantially fill the aperture. Even if one were to combine these references, there is nothing in either of them alone or in combination that would lead one to expect that a discontinuous seed layer in an aperture can be repaired, and more specifically that a discontinuous seed layer can be repaired and that copper can be deposited into an aperture to substantially fill the aperture. In particular: 1) neither Tsai nor Mahapatra disclose or suggest seed layers having discontinuities; 2) neither Tsai nor Mahapatra recognize the problem of discontinuous seed layers; 3) Tsai only discloses acid copper plating baths having a pH of 0.1 to 4; 4) Mahapatra only discloses alkaline copper pyrophosphate baths having a pH of 8.2-8.8; and 5) neither Tsai nor Mahapatra alone or in combination teach or suggest that an alkaline copper pyrophosphate electroplating bath can both repair a discontinuous seed layer in an aperture and deposit copper in an aperture to substantially fill the aperture.

Absent Applicants' own teaching in the Specification, there is nothing in either reference alone or in combination that would motivate one skilled in the art to combine these references. Even if one were to combine these references, there is nothing in this combination that teaches or suggests that an alkaline copper pyrophosphate electroplating bath can both repair a discontinuous seed layer in an aperture and deposit copper in an aperture to substantially fill the aperture. Applicants submit that the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Claims 3, 5, 8 and 10 have been rejected under 35 USC § 103(a) as being unpatentable over Cohen or Tsai in view of Mahapatra and further in view of Kaneko. Applicants respectfully traverse.

Cohen, Tsai and Mahapatra are discussed above alone and in combination.

Kaneko fails to fill the deficiencies of Cohen or Tsai alone or in view of Mahapatra. The Kaneko patent discloses only a pyrophosphoric acid bath for the deposition of a copper-tin alloy. This patent fails to disclose or suggest discontinuous seed layers. In addition, this patent fails to

recognize the need to repair such discontinuous seed layers. Accordingly, this patent neither teaches nor suggests the repair of discontinuous seed layers. Further, this patent fails to teach or suggest substrates having one or more apertures having a size of $\leq 1 \mu\text{m}$.

Even if one were to combine the complexing agent and/or brightener of Kaneko with Mahapatra, such combination still fails to teach or suggest using an alkaline copper pyrophosphate electroplating bath to both repair a discontinuous copper seed layer and deposit copper to fill an aperture.

Accordingly, the combination of Cohen or Tsai with Mahapatra further in view of Kaneko still fails to teach or suggest using an alkaline copper pyrophosphate electroplating bath to both repair a discontinuous copper seed layer and deposit copper to fill an aperture. Absent Applicants' own teaching in the Specification, there is nothing in any of these references alone or in any combination that would motivate one skilled in the art to combine them. Even if one did combine these references, there is nothing in any of them either alone or in combination that teaches or suggests a method of providing metal seed layers substantially free of discontinuities by contacting metal seed layers having discontinuities with a copper pyrophosphate electroplating bath as claimed by Applicants. More specifically, there is nothing in any of these references alone, or in any combination, that teaches or suggests that a copper pyrophosphate may be used to repair a discontinuous seed layer in an aperture and deposit copper metal in the aperture to substantially fill the aperture in one step. See, for example, Applicants' claims 18-20.

Accordingly, Applicants submit the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Favorable reconsideration in the form of a notice of allowance is respectfully requested.

Respectfully submitted,



S. Matthew Cairns, Ph.D.
Attorney for Applicant
Registration No. 42,378

c/o EDWARDS & ANGELL
Dike, Bronstein, Roberts & Cushman IP Group
PO Box 9169
Boston, MA 02209
Date: *October 27, 2013*